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North Central Forest Experiment Station

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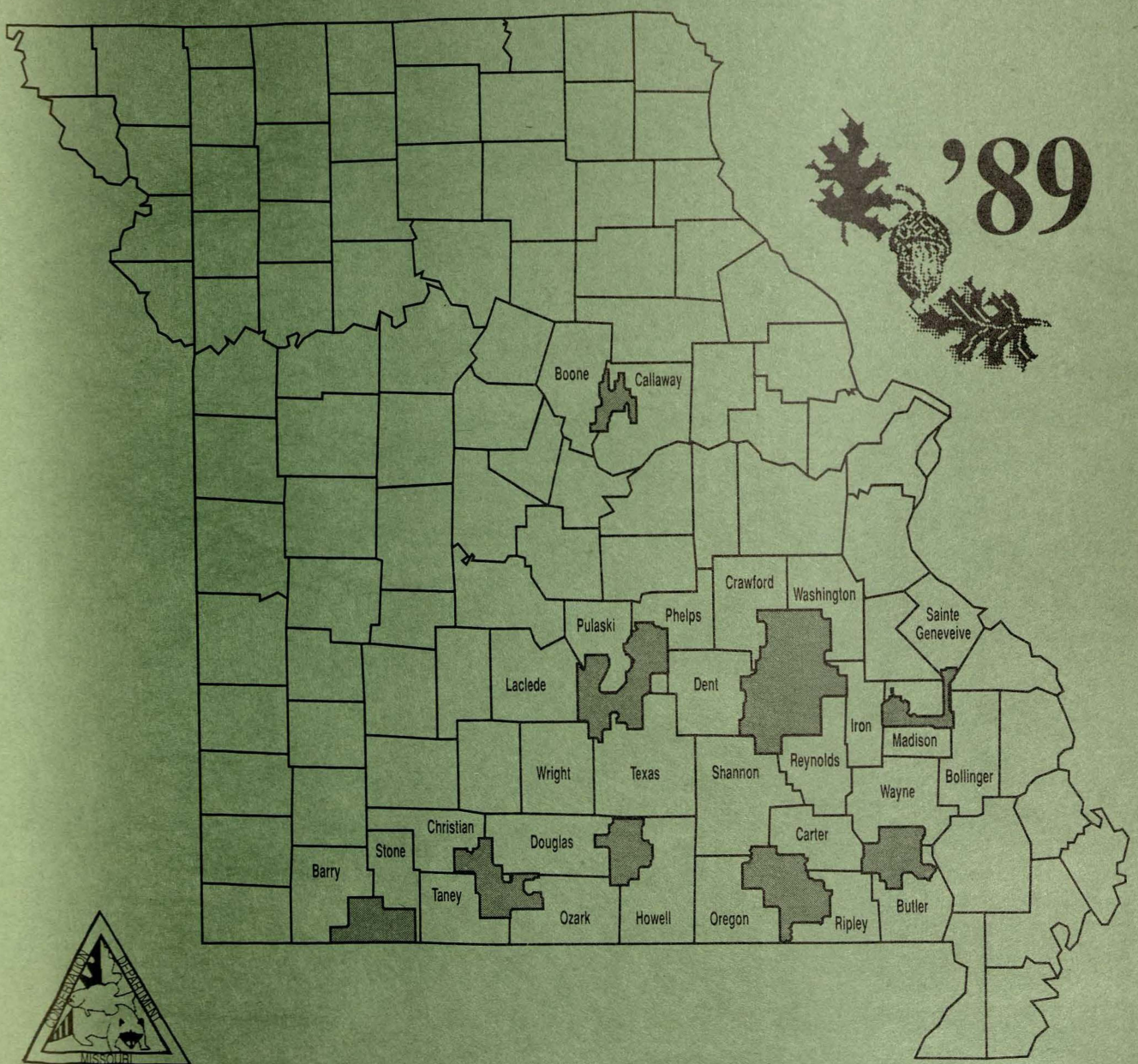
Timber Resource of the Mark Twain National Forest

Neal P. Kingsley and Jay R. Law



North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
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This report includes the most commonly used Forest Inventory and Analysis statistics. However, additional forest resource data can be provided to interested users. Persons requesting additional information that can be provided from the raw inventory data are expected to pay the retrieval costs. These costs range from less than $100 for a relatively simple request to $2,000 for a complex retrieval involving the services of a Forest Inventory and Analysis computer programmer. Requests will be filled so as to minimize the impact on the Forest Inventory and Analysis Work Unit.

Requests for unpublished information may be directed to:

Project Leader
Forest Inventory and Analysis
North Central Forest Experiment Station
1992 Folwell Avenue
St. Paul, Minnesota 55108
Phone: (612) 649-5139

Area served: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin

Requests for unpublished information from the Missouri inventory may also be directed to:

State Forester
Missouri Department of Conservation
Forestry Division
P.O. Box 180
Jefferson City, Missouri 65102
Phone: (314) 751-4115

FOREWORD

Forest Inventory and Analysis (FIA) is a continuing endeavor as mandated by the Renewable Forest and Rangeland Resources Planning Act of 1974. Prior inventories were mandated by the McSweeney-McNary Forest Research Act of 1928. The objective of FIA is to periodically inventory the Nation's forest land to determine its extent, condition, and volume of timber, growth, and removals. Up-to-date resource information is essential to frame forest policies and programs. USDA Forest Service regional experiment stations are responsible for conducting these inventories and publishing summary reports for individual States. The North Central Forest Experiment Station is responsible for forest inventory and analysis in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin.

Fieldwork for the Missouri statewide forest inventory was begun in January 1987 and completed in June 1989. Reports of the three previous inventories of Missouri's timber resource are dated 1947, 1959, and 1972.

Aerial photos used in the Missouri Forest Inventory were furnished by the USDA Agricultural Stabilization and Conservation Service and the Missouri Department of Natural Resources, Geology and Land Survey.

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NOTE: *The 1989 forest inventory of the State of Missouri marks the fifth time that the forest resources of National Forest lands in the State have been surveyed. In 1977, the inventory plots established on the Mark Twain National Forest in 1972 as part of the third statewide forest inventory were remeasured. The results of this remeasurement were considered in the Forest's Resource Management Plan, which was approved in 1986. Plots were not remeasured in 1977 in any other part of Missouri. Therefore, 1972 is the previous forest inventory for all other ownership classes in the state. Data from the 1972, 1977, and 1989 inventories of the National Forest are compared in the next column:*

	1972	1977	1989
Timberland (Thousand acres)	1,321.8	1,332.4	1,320.9
All forest land (Thousand acres)	1,352.4	1,363.4	1,434.2
Growing-stock volume (Million cubic feet)	831.9	914.0	1,151.2
Sawtimber volume (Million board feet)	2,187.4	2,735.3	3,353.3

Data from new forest inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for comparisons to be valid, the procedures used in the two inventories must be similar. As a result of on-going efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred between 1977 and 1989. To facilitate comparison of inventories, the 1977 inventory data have been reprocessed using 1989 procedures. Please refer to the Appendix section of this report entitled "Comparing the Mark Twain National Forest's 1977 Inventory with the 1989 Inventory."

The Land and Resource Management Plan of the Mark Twain bases timber outputs on lands defined as suited for timber production. "Timberland" in this publication is defined as all forested land capable of producing 20 cubic feet of usable wood per acre per year and not withdrawn from timber production. Because of these different definitions, estimates shown here will not always be comparable with those in the Mark

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Neal P. Kingsley, Research Forester, received his bachelor's degree in forestry and his master's degree in forest economics from the University of New Hampshire. He spent 25 years with the Northeastern Forest Experiment Station before joining the North Central Forest Experiment Station as Project Leader of the Forest Inventory and Analysis project.

Jay R. Law received his bachelor's degree in forestry and master's degree in silviculture from Purdue University. In his 30-year career with the Eastern Region of the Forest Service, he served as Project Leader of timber inventories on two Lake States National Forests, as District Ranger on the Harrisville and Baldwin Districts of the Huron-Manistee National Forest, as a staff specialist on the Region's Forest Plans and Silviculture groups, and as Timber Staff Officer on the Mark Twain National Forest. He retired from the Forest Service in 1990.

Twain's Land and Resource Management Plan. The acreage shown in the Land and Resource Management Plan is the basis for resource management on the National Forest.

General

The Mark Twain, located in the south-central part of Missouri is the only National Forest in the State. National Forest lands, totaling nearly 1 1/2 million acres, are found in 29 counties. They account for only 3 percent of the State's land area, but 11 percent of the State's forest land.

The Forest lies mostly within the Ozark Plateau, which consists of remnant hills from the country's oldest mountains, the Ozarks. The connecting ridges, deep hollows, rocky knobs, and cedar glades of the Forest today scarcely reveal the hard times of the past that affected both the land and its people. By 1913, the virgin pine and oak-hickory forests of the Ozark region were gone. Settlers had cleared the land and burned large areas annually to encourage wild grasses to feed free roaming livestock. By the mid-1920's the thin, infertile upland soils began to fail. Forage and row crop production declined. By 1930, the country's troubled economy dealt the region a financial blow. Failing lands and failing finances forced the sale or abandonment of many Ozark farms.

Through acts of the Missouri Legislature and the U.S. Congress, the Secretary of Agriculture was authorized, beginning in 1934, "to buy forested, cutover, or denuded lands to regulate the flows of navigable waters or for timber production." Land purchases began in 1934, and the Mark Twain National Forest was formally established in 1939.

At the time of the first Missouri inventory in 1947, less than 27 percent of the Mark Twain was in forested areas where sawtimber-sized trees predominated. There was less than 1 billion board feet of sawtimber on the Forest. Today the Mark Twain has nearly 3.4 billion board feet of sawtimber. Nearly all the land within the Forest is in forest cover, where more than 300 species of wildlife live. Congress has designated seven Wilderness Areas and a Wild and Scenic River within the Mark Twain.

Further information about the Mark Twain and its resources is available from:

Supervisor
Mark Twain National Forest
401 Fairgrounds Road
Rolla, MO 65401

HIGHLIGHTS

Forest Area

The timberland area of the Mark Twain National Forest declined slightly between 1977 and 1989, from 1,332,400 acres to 1,320,900 acres. Most of this change was as a result of reclassification of timberland to reserved forest land. Reserved timberland is as productive as timberland but is reserved from harvesting as part of wilderness or other special use areas. In 1989, there were 79 thousand acres of reserved timberland.

The oak forest types dominate the forest. Three oak types—post-blackjack oak, black-scarlet oak, and white oak—account for nearly 75 percent or 987 thousand acres of the timberland area. Two other important types, shortleaf pine and shortleaf pine-oak, account for 21 percent or 273.3 thousand acres of the timberland. Although the total acreage of timberland has declined very little, there have been some significant changes in the area of some forest types. For instance, the area of black-scarlet oak declined from 642.3 thousand acres in 1977 to 564.4 thousand acres in 1989 (fig. 1). This change reflects the impact of oak decline and increases in white oak forest type.

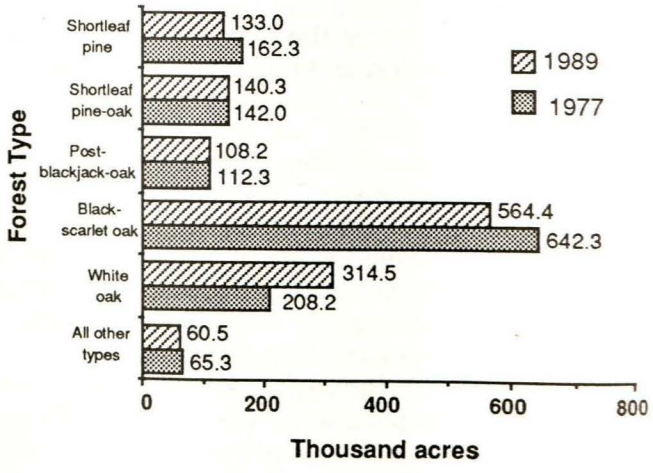

Figure 1.—*Forest type changes by major forest type on the Mark Twain National Forest, 1977-1989.*

The size of timber on the Mark Twain has increased considerably during the 12-year period. The area of sawtimber-size stands increased from 589.1 thousand acres in 1977 to 690.6 thousand in 1989, an increase of nearly 17 percent. Conversely, the area in poletimber-size stands dropped 21 percent (fig. 2). This increase in the acreage of sawtimber-size stands reflects the maturing of the forest.

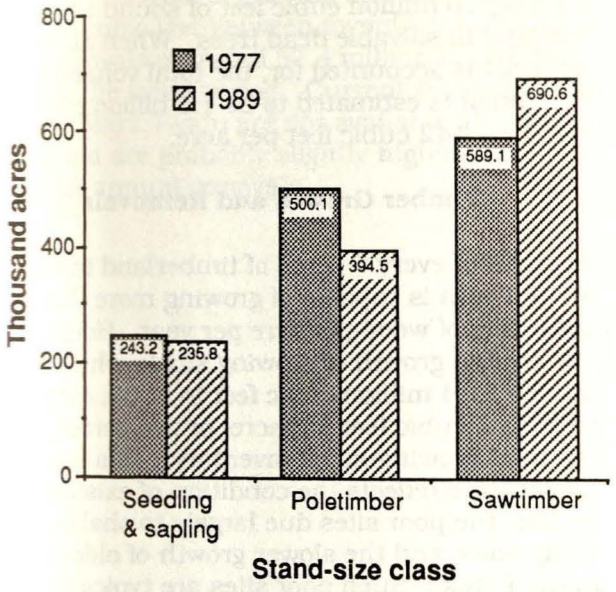

Figure 2.—*Stand-size class change on the Mark Twain National Forest, 1977-1989.*

Volume

In 1989 the volume of growing stock was nearly 1.2 billion cubic feet, up from 946.9 million in 1977—a gain of nearly 22 percent. Today, the average acre on the Mark Twain contains 871 cubic feet of growing stock, compared to 710 in 1977.

The change in stand-size classes is an indication of what has happened to timber volumes on the National Forest between the 1977 and 1989 inventories. Sawtimber volume gained 32 percent over the 12-year period, from 2.6 billion board feet in 1977 to nearly 3.4 billion in 1989. Among species groups, the largest gain was in the hard hardwood group, which rose by almost 32 percent from 1.7 to 2.2 billion board feet between inventories. Select white oak volume increased nearly 50 percent; the other red oak group had a 34-percent gain.

Oak species account for 65 percent of the growing stock on the Forest (747 million cubic feet) and 62 percent of the sawtimber volume (2.1 billion board feet) (fig. 3). Other red oaks, principally black and scarlet oaks, are the most abundant species on the Forest. This species group accounts for 389 million cubic feet of growing stock and 1.2 billion board feet of sawtimber. The select white oak group, predominantly white oak and bur oak, is the second most abundant hardwood species group. These species account for 266 million cubic feet of growing stock and 653 million board feet of sawtimber. Shortleaf pine, which accounts for 296 million cubic feet of growing stock and 1.0 billion board feet of sawtimber, is the second most abundant species group on the Mark Twain.

Timber Quality

Much of the acquired land in what is now the Mark Twain National Forest has an early history of misuse—overgrazing, repeated wildfire, and

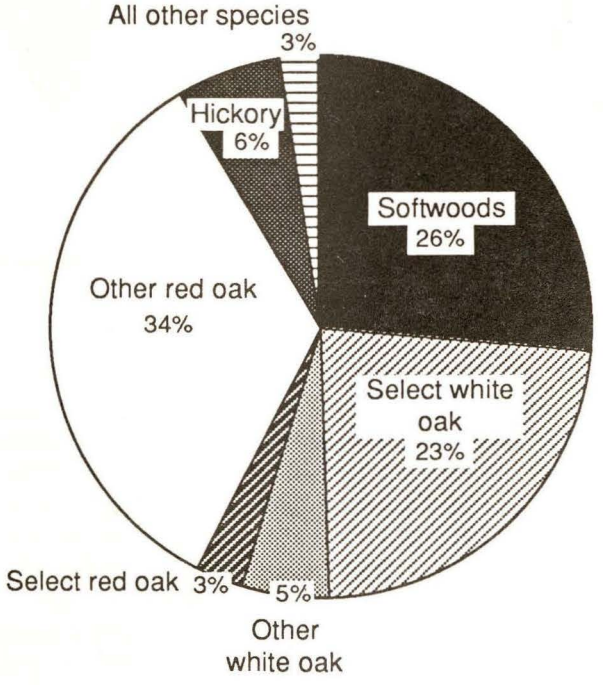

Figure 3.—*Volume of growing stock by major species group on the Mark Twain National Forest, 1989.*

poor timber harvesting practices. This past abuse has contributed to the prevalence of poor growing conditions there. About 40 percent of the timberland in the Forest is not capable of growing more than 50 cubic feet per acre per year. These poor sites also contribute to the generally poor quality of the timber. More than two-thirds of the hardwood sawtimber is in trees with a tie and timber butt log grade (fig. 4). These logs cannot be satisfactorily sawn into grade lumber.

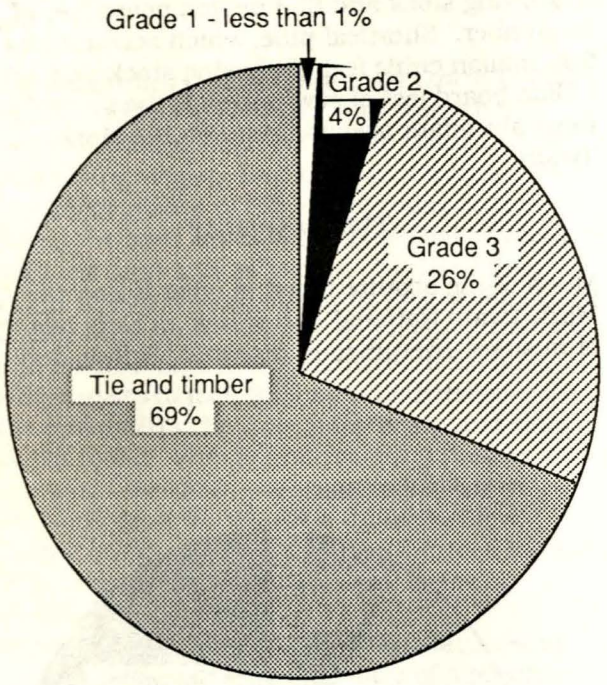

Figure 4.—*Volume of hardwood sawtimber by butt log grade on the Mark Twain National Forest, 1989.*

Shortleaf pine and select white oaks, two of the species groups that have increased the most in volume, are also the only species groups that have any significant volume in trees with a grade 1 butt log. More than 11 percent of the select white oak and 24 percent of the shortleaf pine volume is in trees with grade 1 or 2 butt logs. The fact that these generally better quality species are on the increase reflects better land management practices and the protection of forest lands from repeated wildfires.

In addition to the Mark Twain's 1.2 billion cubic feet in growing-stock trees, there are 61.4 million cubic feet in short-log trees. These trees do not contain a minimum 12-foot saw log or two noncontiguous 8-foot saw logs, and are, therefore, not classed as growing-stock trees. In addition to this material, there are 219.4 million cubic feet of sound material in trees that are too rough and 60.8 million in trees that are too rotten to be considered growing stock. There are also 16 million cubic feet of sound usable material in salvable dead trees. When all usable material is accounted for, the total volume in the Forest is estimated to be 1.5 billion cubic feet, or 1,142 cubic feet per acre.

Timber Growth and Removals

Nearly 3 of every 5 acres of timberland in the Mark Twain is capable of growing more than 50 cubic feet of wood per acre per year. However, net annual growth of growing stock, which totaled 31.4 million cubic feet in 1988, averaged only 23.7 cubic feet per acre, or 2.7 percent of the total growing-stock inventory. This low growth rate reflects the condition of existing timber, the poor sites due largely to shallow, rocky soils, and the slower growth of older trees in the Forest. Such poor sites are typical of conditions found in south-central Missouri. Annual growth of sawtimber totaled 108.1 million board feet, 81.8 board feet per acre in 1988.

Mortality of growing-stock trees totaled 9.7 million cubic feet in 1988, or 0.8 percent of the inventory. The other red oak species group had the highest annual mortality of any species group at 5.8 million cubic feet or 1.5 percent of the inventory in that species group (fig. 5). Sawtimber mortality in the Forest was 20.1 million board feet in 1988. Fifty-nine percent of this mortality was in the other red oak group. The reason for this high mortality in the red oak species group is oak decline, an umbrella term given to mortality caused by a complex interaction of environmental stresses such as drought, late spring frosts, insects, or diseases. Trees weakened by these stresses are invaded and

killed by insects or diseases that cannot successfully attack healthy trees. The entire process may take several years. Black and scarlet oaks, particularly on burned-over shortleaf pine sites, appear to be most susceptible to oak decline. The red oak species group has been declining in this region of Missouri since the late 1970's.

Annual removals of growing stock averaged 18.1 million cubic feet between inventories. Sawtimber removals averaged 57.4 million board feet during the same period. Current removals data for the Mark Twain are not available at this time, but are probably slightly higher than average annual removals.

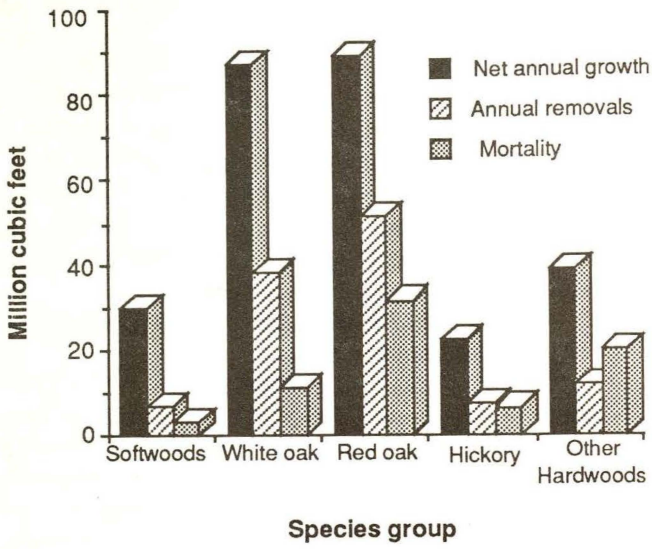

Figure 5.—*Average annual growth, removals, and mortality of growing stock on timberland by major species group, Mark Twain National Forest, 1989.*

APPENDIX

ACCURACY OF SURVEY

Forest Inventory and Analysis information is based on a sampling procedure designed to provide reliable statistics at the State and Survey Unit levels. Consequently, the reported figures are estimates only. A measure of reliability of these figures is given by sampling errors. These sampling errors mean that the chances are two out of three that if a 100-percent inventory had been taken, using the same methods, the results would have been within the limits indicated.

For example, the estimated growing-stock volume in the National Forest in 1989, 1,151.2 million cubic feet, has a sampling error of ±3.3 percent (±38.0 million cubic feet). The growing-stock volume from a 100-percent inventory would be expected to fall between 1,113.2 and 1,189.2 million cubic feet (1,151.2 ± 38.0), there being a one in three chance that this is not the case.

The tabulation on the next page shows the sampling errors for the 1989 Mark Twain National Forest Inventory:

Item	Unit totals	Sampling error
	Million cubic feet	*Percent*
Growing stock		
Volume (1989)	1,151.2	3.3
Average annual growth (1977-1988)	31.4	7.6
Average annual removals (1977-1988)	18.1	14.0
	Million board feet	
Sawtimber		
Volume (1989)	3,353.3	4.7
Average annual growth (1977-1988)	127.3	8.9
Average annual removals (1977-1988)	57.4	16.0
	Thousand acres	
Timberland area (1989)	1,473.7	enumerated

As survey data are broken down into sections smaller than Survey Unit totals, the sampling error increases. For example, the sampling error for timberland area in a particular county is higher than that for total timberland area in the National Forest. This tabulation shows the sampling errors for National Forest totals. To use this information for data smaller than National Forest totals, use the following formula to compute error estimates:

$$E = \frac{(SE)\sqrt{\text{(National Forest total area or volume)}}}{\sqrt{\text{(Volume or area smaller than National Forest)}}}$$

where:

E = sampling error in percent
SE = Forest total error for area or volume

For example, to compute the error on the volume of other red oak growing stock, proceed as follows:

The total volume of other red oak from table 7 = 388.7 million cubic feet

The total volume of all growing stock from table 7 = 1,151.0 million cubic feet

The total error for growing-stock volume from the above tabulation = 3.3 percent

Then to determine the error for other red oak growing stock:

$$\text{Error} = \frac{(3.3)\sqrt{1{,}151.0}}{\sqrt{388.7}}$$

$$= \pm 5.7 \text{ percent}$$
(or ± 21.2 million cubic feet)

SURVEY PROCEDURES

These were the major steps in the survey design:

1. Aerial photography (Phase 1)

In this phase two sets of random points were located on current aerial photography. The first is a set of new photo plots and the second is a set of relocated old photo plots (ground plot locations from the previous inventory). Photos were 1:20,000 and 1:40,000 scale black and white panchromatic prints provided by the ASCS and the Missouri Department of Natural Resources, Geology and Land Survey. The year of photography for each county that contains National Forest land is shown on the next page.

County	Date	County	Date
Barry	1979	Ozark	1981
Bollinger	1981	Phelps	1981
Boone	1977	Pulaski	1981
Butler	1981	Reynolds	1982
Callaway	1982	Ripley	1982
Carter	1981	St. Francois	1981
Christian	1982	Ste. Genevieve	1981
Crawford	1981	Shannon	1981
Dent	1981	Stone	1981
Douglas	1981	Taney	1981
Howell	1981	Texas	1981
Iron	1982	Washington	1981
Laclede	1981	Wayne	1981
Madison	1981	Wright	1981
Oregon	1981		

The locations of the plots used in the 1972 inventory were transferred to these new photographs. The photographs were then assembled into township mosaics, and a systematic grid of 121 one-acre photo plots (each plot representing approximately 190.4 acres) was overlaid on each township mosaic. Each of these plots (both the new systematic grid points and the old sample plots) was examined by aerial photogrammetrists and classified stereoscopically based on land use. If trees were present, forest type and stand size-density class were recorded. Then all the old sample locations and a sample of the new photo plots were sent to the field for the field crew to verify the photo classification and to take further measurements. A total of 7,611 photo plots was examined stereoscopically as shown in the following tabulation.

Photo land class	Photo plots
Timberland	7,123
Reserved timberland	199
Questionable	0
Nonforest with trees	188
Nonforest without trees	101
Water (Census)	0
All classes	7,611

2. Plot measurements (Phase 2)

On plots classified as timberland, wooded pasture, or windbreak (at least 120 feet wide), a ground plot was established, or remeasured. Ground plots consist of a 10-point cluster covering approximately 1 acre. At each point, trees 5.0 inches or more in d.b.h. were sampled on a 37.5 Basal Area Factor (BAF) variable-radius plot, and trees less than 5.0 inches d.b.h. were sampled on a 1/300-acre fixed-radius plot.

From the new photo plots, a random sample of 188 new ground plots was established, and measures of land use, volume, mortality and cutting were recorded. These locations were monumented for future remeasurement. Ground plots corresponding to old inventory photo plots were remeasured to obtain current land use, volume, growth and removals information.

This procedure yielded two independent samples, one coming from the new photo points and the other from the old photo points that are remeasured or updated. The following tabulation summarizes the distribution of ground plots for the new inventory design:

Ground land use class	Old plots remeasured	Old plots updated	Old plots replaced	New plots	Total plots
Timberland	227	4	1	99	331
Reserved forest land	14	1	0	69	84
Other forest land	11	0	0	0	11
Nonforest with trees	0	0	0	0	0
Nonforest without trees	6	1	1	20	28
Water	0	0	0	0	0
Total	258	6	2	188	454

3. Area estimates

The total area of National Forest land was supplied by the forest staff. For this reason, it is considered an enumeration without an associated sampling error.

Area estimates within the Mark Twain National Forest were obtained from compartment examination records maintained by the Forest. This is an intensive area inventory system in which, over a period of years, each stand in the Forest is mapped on aerial photographs and then classified by ground visits.

4. Volume estimates

Estimates of volume per acre were made from the trees measured on the 10-point plots. Estimates of volume per acre were multiplied by the area estimates to obtain estimates of total volume. Net cubic foot volumes are based on equations developed by Hahn and Hansen[1] for use in the Central States.

The Forest Service reports all board foot volume in International 1/4-inch rule. In Missouri, the Doyle log rule is commonly used. Doyle log rule conversion factors were derived from full tree measurements taken throughout the Central States (Illinois, Indiana, Iowa, and Missouri) and an equation developed by Wiant and Castenaeda 1977[2]. The factors (multipliers) used here to convert board foot International volumes to the Doyle rule are shown in the following tabulation:

D.B.H. (inches)	Doyle rule conversion factor	
	Softwoods	Hardwoods
9.0-10.9	0.3455	—
11.0-12.9	.4780	0.4172
13.0-14.9	.5992	.5118
15.0-16.9	.6908	.5882
17.0-18.9	.7685	.6569
19.0-20.9	.8573	.7180
21.0-22.9	.8645	.7829
23.0-24.9	.9276	.8324
25.0-26.9	.9493	.8736
27.0-28.9	.9710	.9473
29.0+	1.1065	1.1349

5. Growth and mortality estimates

On remeasured plots, estimates of growth and mortality per acre come from the remeasured diameters of trees and from observation of trees that died between inventories. Growth is reported for 1988, the last year before the inventory, and is based on an assumption of constant basal area growth over the remeasurement period. Mortality is reported for 1988 also, and is based on an assumption of constant volume mortality over the remeasurement period. On new plots, where trees were not remeasured, estimates of growth and mortality were obtained by using the Central States Stand and Tree Evaluation and Modeling System (STEMS)[3] to project the growth and mortality of trees for 1 year. As with volume, total growth and mortality estimates were obtained by multiplying the per acre estimates by the area.

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[1] *Hahn, Jerold T.; Hansen, Mark H. Tree volume equations for the Central States. Northern Journal of Applied Forestry. In press.*

[2] *Wiant, Harry V., Jr.; Castenaeda, Froylan. 1977. Mesavage and Girard's volume tables formulated. BLM4. Denver, CO: U.S. Department of Interior, Bureau of Land Management, Denver Service Center: 1-4.*

[3] *Shifley, S.F. 1987. A generalized system of models forecasting central states tree growth. Res. Pap. NC-279. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 10 p.*

6. Average annual removals estimates

Average annual growing-stock and sawtimber removals (1976 to 1988) were estimated only from the remeasured plots; new plots were not used to estimate removals. These estimates are obtained from trees measured in the previous survey and cut or otherwise removed from the timberland base. Because remeasurement plots make up about 60 percent of the total ground plots, average annual removals estimates have greater sampling errors than volume and growth estimates.

COMPARING THE MARK TWAIN NATIONAL FOREST'S 1977 INVENTORY WITH THE 1989 INVENTORY

The following paragraphs highlight some of the procedural changes since the last inventory to assist the reader in analyzing data from this report:

New volume equations were developed for the Central States, and these equations were used to compute the 1989 volumes and also to recompute the 1977 volume for growth calculations. Although the adjustment differs by Survey Unit, the recomputed 1977 growing-stock and board foot volumes will generally be greater than reported.

Mortality figures published in the 1977 inventory were based on field estimates from a limited number of remeasurement plots. Information gathered on a larger number of remeasurement plots during the current inventory was used to adjust the 1977 mortality figures. This adjustment will also affect the estimate of net growth for the 1977 inventory.

Past surveys used only growing-stock trees to determine stand-size class. Current survey procedures require that stand-size class be determined on the basis of all live trees. Therefore, direct comparisons of current inventory data to old inventory data by stand-size class may be misleading.

The basic building block for estimating forest area and timber volume has been changed from the Survey Unit to the county. In the past, the statistics were developed at the unit level and prorated back to the county on the basis of photo-interpretation points. Direct development of county-level data helps users interested in more precise local data, but can make the outcome of comparisons with past estimates uncertain.

LOG GRADE

In Missouri and in the Mark Twain National Forest, the butt log of every sawtimber sample tree was graded for quality on approximately one-third of the sample plots. The volume yield by log grade for species in this sample was used to distribute the volume of trees in the ungraded sample into butt log-grade classes by species group.

Butt logs were graded on the basis of external characteristics as indicators of quality. Hardwood species were graded according to "A guide to hardwood log grading"[4]. The best 12-foot section of the lowest 16-foot hardwood log, or the best 12-foot upper section if the butt log did not meet minimum log-grade standards, was graded as follows:

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[4] *Rast, Everette D.; Sonderman, David L.; Gammon, Glenn L. 1973. A guide to hardwood log grading. Gen. Tech. Rep. NE-1. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 31 p.*

Forest Service standard grades for hardwood factory saw logs

Grading Factors		Specifications							
		Log grade 1			Log grade 2				Log grade 3
Position in tree		Butts only	Butts & uppers		Butts & uppers				Butts & uppers
Scaling diameter, inches		13-15[1]	16-19	20+	11+[2]		12+		8+
Length without trim, feet			10+		10+	8-9	10-11	12+	8+
Required clear cuttings[3] of each of three best faces[4]	Min. length, feet	7	5	3	3	3	3	3	2
	Max. number		2	2	2	2	2	3	No limit
	Min. proportion of log length required in clear cutting	5/6	5/6	5/6	2/3	3/4	2/3	2/3	1/2
Maximum sweep & crook allowance	For logs with less than one-fourth of end in sound defects		15 percent				30 percent		50 percent
	For logs with more than one-fourth of end in sound defects		10 percent				20 percent		35 percent
Maximum scaling deduction			40 percent[5]				50 percent[6]		50 percent

[1] *Ash and basswood butts can be 12 inches if they otherwise meet requirements* for small #1's.
[2] *Ten-inch logs of all species can be #2 if they otherwise meet requirements for small #1's.*
[3] *A clear cutting is a portion of a face, extending the width of the face, that is free of defects.*
[4] *A face is one-fourth of the surface of the log as divided lengthwise.*
[5] *Otherwise #1 logs with 41-60 percent deductions can be #2.*
[6] *Otherwise #2 logs with 51-60 percent deductions can be #3.*

Forest Service standard specifications for hardwood construction logs (tie and timber logs)[1]

Position in tree	Butts and uppers
Min. diameter, small end	8 inches +
Min. length without trim	8 feet
Clear cuttings	No requirements
Sweep allowance	One-fourth of the diameter at the small end for each 8 feet of length.
Sound surface defects:	
Single knots	Any number, if no one knot has an average diameter above the callus in excess of one-third of the log diameter at point of occurrence.
Whorled knots	Any number, if the sum of knot diameters above the callus does not exceed one-third of the log diameter at point of occurrence.
Holes	Any number, provided none has a diameter over one-third of the log diameter at point of occurrence and none extends more than 3 inches into included timber[2].
Unsound surface defects :	Same requirements as for sound defects if they extend into included timber. No limit if they do not.

[1] *These specifications are minimum for the class. If, from a group of logs, factory logs are selected first, thus leaving only nonfactory logs from which to select construction logs, then the quality range of the construction logs so selected is limited, and the class may be considered a grade. If selection for construction logs is given first priority, it may be necessary to subdivide the class into grades.*

[2] *Included timber is always square, and dimension is judged from small end.*

Log Grades for Southern pine logs

Grade 1: logs with three or four clear faces[1] and 16" minimum d.i.b.

Grade 2: logs with one or two clear faces and 12" minimum d.i.b.

Grade 3: logs with no clear faces and 6" minimum d.i.b.

After the tentative log grade is established from above, the log will be degraded one grade for each of the following, except that no log can be degraded below grade 3. Net scale after deduction for defect must be at least 50 percent of the gross contents of the log.

1. *Sweep.* Degrade any tentative 1 or 2 log one grade if sweep amounts to 3 or more inches and equals or exceeds one-third of the diameter inside bark at small end.

2. *Heart rot.* Degrade any tentative 1 or 2 log one grade if conk, massed hyphae, or other evidence of advanced heart rot is found anywhere in it.

[1] *A face is one-fourth of the circumference in width extending full length of the log. Clear faces are those free of: knots measuring more than inch in diameter, overgrown knots of any size, and holes more than one inch in diameter. Faces may be rotated to obtain the maximum number of clear ones.*

Log Grades for eastern redcedar

(Missouri special use)

Position in tree	Butts and uppers
DBH	6 inches +
Min. diameter(ob), small end	5 inches +
Length without trim	7 feet
Clear cuttings	No requirements
Sweep allowance	Reasonably straight
Sound surface defects permitted:	
Single knot	Any number less than one-half of the log diameter at point of occurrence.
Whorled knots	Any number provided the sum of the diameter of knots 2 inches or larger in a 1-foot section does not exceed the diameter at that point.
Unsound defects permitted:	Any number, provided defect is not greater than one-half of the volume at any one point of occurrence.

METRIC EQUIVALENTS OF UNITS USED IN THIS REPORT

1 acre = 4,046.86 square meters or 0.405 hectare.
1,000 acres = 405 hectares.
1 cubic foot = 0.0283 cubic meter.
1 foot = 30.48 centimeters or 0.3048 meter.
1 inch = 25.4 millimeters, 2.54 centimeters, or 0.0254 meter.
1 pound = 0.454 kilograms.
1 ton = 0.907 metric tons.

COMMON TREE SPECIES GROUPS OF THE MARK TWAIN NATIONAL FOREST[5]

SOFTWOODS
Shortleaf pine ..... *Pinus echinata*
Virginia pine ..... *Pinus virginiana*
Eastern redcedar ..... *Juniperus virginiana*
HARDWOODS
Select white oak[6]
White oak ..... *Quercus alba*
Swamp white oak ..... *Quercus bicolor*
Bur oak ..... *Quercus macrocarpa*
Swamp chestnut oak ..... *Quercus michauxii*
Chinkapin oak ..... *Quercus muehlenbergii*
Other white oak[6]
Overcup oak ..... *Quercus lyrata*
Chestnut oak ..... *Quercus prinus*
Post oak ..... *Quercus stellata*
Select red oak[6]
Cherrybark oak ..... *Quercus falcata var. pagodifolia*
Northern red oak ..... *Quercus rubra*
Shumard oak ..... *Quercus shumardii var. shumardii*
Other red oak[6]
Scarlet oak ..... *Quercus coccinea*
Northern pin oak ..... *Quercus ellipsoidalis*
Southern red oak ..... *Quercus falcata*
Shingle oak ..... *Quercus imbricaria*
Black oak ..... *Quercus velutina*
Blackjack oak ..... *Quercus marilandica*
Pin oak ..... *Quercus palustris*
Willow oak ..... *Quercus phellos*
Select hickory[6]
Pecan ..... *Carya illinoensis*
Shellbark hickory ..... *Carya lacinosa*
Shagbark hickory ..... *Carya ovata*
Mockernut hickory ..... *Carya tomentosa*
Other hickory[6]
Bitternut hickory ..... *Carya cordiformis*
Pignut hickory ..... *Carya glabra*
Black hickory ..... *Carya texana*
River birch[6] ..... *Betula nigra*
Hard maple[6]
Sugar maple ..... *Acer saccharum*
Soft maple[7]
Red maple ..... *Acer rubrum*
Silver maple ..... *Acer saccharinum*
Ash[6]
Blue ash ..... *Fraxinus quadrangulata*
White ash ..... *Fraxinus americana*
Green ash ..... *Fraxinus pennsylvanica*
Basswood[7] ..... *Tilia americana*
Black walnut[6] ..... *Juglans nigra*
Black cherry[7] ..... *Prunus serotina*
Butternut[7] ..... *Juglans cinerea*
Elm
Winged elm[7] ..... *Ulmus alata*
American elm[7] ..... *Ulmus americana*
Slippery elm[7] ..... *Ulmus rubra*
Rock elm[6] ..... *Ulmus thomasii*
Hackberry[7] ..... *Celtis occidentalis*
Sycamore[7] ..... *Platanus occidentalis*
Black willow[7] ..... *Salix nigra*
Sweetgum[7] ..... *Liquidambar styraciflua*
Tupelo[7]
Black tupelo ..... *Nyssa sylvatica var. sylvatica*
Swamp tupelo ..... *Nyssa sylvatica var. biflora*
Persimmon[6] ..... *Diospyros virginiana*
Sassafras[7] ..... *Sassafras albidum*
Other hardwoods
Ohio buckeye[7] ..... *Aesculus glabra*
Boxelder[7] ..... *Acer negundo*
Kentucky coffeetree[6] ..... *Gymnocladus dioicus*
Black locust[6] ..... *Robinia pseudoacacia*

[5] *The common and scientific names are based on: Little, Elbert L. 1979. Checklist of native and naturalized trees of the United States. Agric. Handb. 541. Washington, DC; U.S. Department of Agriculture, Forest Service. 375 p.*

[6] *This species or species group is considered a hard hardwood, with an average specific gravity greater than or equal to 0.50.*

[7] *This species or species group is considered a soft hardwood, with an average specific gravity of 0.50 or less.*

White mulberry[7] ..... *Morus alba*
Red mulberry[7] ..... *Morus rubra*
Honeylocust[6] ..... *Gleditsia triacanthos*
Northern catalpa[6] ..... *Catalpa speciosa*
Noncommercial species
Osage-orange ..... *Maclura pomifera*
Eastern hophornbeam ..... *Ostrya virginiana*
Apple ..... *Malus* spp.
American hornbeam ..... *Carpinus caroliniana*
Wild plum ..... *Prunus* spp.
Eastern redbud ..... *Cercis canadensis*
Pawpaw ..... *Asimina triloba*
Hawthorn ..... *Crataegus* spp.

DEFINITION OF TERMS

Average annual removals from growing stock.—The average net growing-stock volume in growing-stock trees removed annually for forest products (including roundwood products and logging residues) and for other uses (see Other removals). Average annual removals of growing stock are reported for a period of several years (1977 to 1988 in this report) and are based on information obtained from remeasurement plots (see Survey Procedures in Appendix).

Average annual removals from sawtimber.—The average net board foot sawtimber volume of live sawtimber trees removed annually for forest products (including roundwood products and other uses [see Other removals]). Average annual removals of sawtimber are reported for a period of several years (1977 to 1988 in this report) and are based on information obtained from remeasurement plots (see Survey Procedures in Appendix).

Basal area.—The area in square feet of the cross section at breast height of a single tree. When the basal area of all trees in a stand is summed, the result is usually expressed as square feet of basal area per acre.

Commercial species.—Tree species presently or prospectively suitable for industrial wood products. (Note: Excludes species of typically small size, poor form, or inferior quality such as hophornbeam, osage-orange, and redbud.)

Cull.—Portions of a tree that are unusable for industrial wood products because of rot, missing or dead material, or other defect.

Diameter class.—A classification of trees based on diameter outside bark, measured at breast height (d.b.h.). Two-inch diameter classes are commonly used in Forest Inventory and Analysis, with the even inch the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Diameter at breast height (d.b.h.).—The outside bark diameter at 4.5 feet (1.37m) above the forest floor on the uphill side of the tree. For determining breast height, the forest floor includes the duff layer that may be present, but does not include unincorporated woody debris that may rise above the ground line.

Forest land.—Land at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparing specified standards with basal area and/or number of trees, age or size, and spacing.) The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas shall be classed as forest if less than 120 feet wide. (See Tree, Land, Timberland, Reserved forest land, Other forest land, Stocking, and Water.)

Forest type.—A classification of forest land based on the species forming a plurality of live tree stocking. Major forest types in the Mark Twain National Forest are:

Shortleaf pine.—Forests in which shortleaf pine comprises a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Eastern redcedar.—Forests in which eastern redcedar comprises a plurality of the stocking. (Common associates include oak and hickory.)

Eastern redcedar-hardwood.—Forests in which hardwoods (usually upland oaks), comprise a plurality of the stocking but where eastern redcedar comprises 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Shortleaf pine-oak.—Forests in which hardwoods (usually white, scarlet, chestnut, northern red, or black oaks), singly or in combination, comprise a plurality of the stocking but where shortleaf pine comprises 25 to 50 percent of the stocking.

Post-blackjack oak.—Forests in which post or blackjack oaks, singly or in combination, comprise a plurality of the stocking, and less than 25 percent of the stocking is in pines or eastern redcedar.

Black-scarlet oak.—Forests in which black oak or scarlet oaks, singly or in combination, comprise a plurality of the stocking, and less than 25 percent of the stocking is in pines or eastern redcedar. (Common associates include yellow-poplar, elm, maple, and black walnut.)

White oak.—Forests in which white oak species, singly or in combination, comprise a plurality of the stocking, and less than 25 percent of the stocking is in pines or eastern redcedar.

Maple-beech.—Forests in which hard maple or beech, singly or in combination, comprise a plurality of the stocking. (Common associates include soft maple, elm, and basswood.) In Missouri, beech is seldom present. Lowland hardwood species such as river birch and sycamore are commonly associated with this type in Missouri.

Growing-stock tree.—A live tree of commercial species that meets specified standards of size, quality, and merchantability. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.—Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0 inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

Hard hardwoods.—Hardwood species with an average specific gravity greater than 0.50 such as oaks, hard maple, hickories, and ash.

Hardwoods.—Dicotyledonous trees, usually broad-leaved and deciduous. (See Soft hardwoods and Hard hardwoods.)

Industrial wood.— All roundwood products, except fuelwood.

Land.—*(A) Bureau of the Census.* Dry land and land temporarily or partly covered by water such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than one-eighth of a statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area.

(B) Forest Inventory and Analysis. The same as the Bureau of the Census, except minimum width of streams, etc., is 120 feet and minimum size of lakes, etc., is 1 acre.

Log grade.—A log classification based on external characteristics as indicators of quality or value. (See Appendix for specific grading factors used.)

Merchantable.—Refers to a pulpwood or saw-log section that meets pulpwood or saw-log specifications, respectively.

Mortality.—The volume of sound wood in growing-stock and sawtimber trees that die annually.

National Forest land.—Federal land that has been legally designated as National Forest or purchase units, and other land administered by the USDA Forest Service.

Net annual growth of growing stock.— The annual change in volume of sound wood in live sawtimber and poletimber trees and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes.

Net annual growth of sawtimber.—The annual change in the volume of live sawtimber trees and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes.

Net volume.—Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Noncommercial species.—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land.—Land that has never supported forests, and land formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide and more than 1 acre in area to qualify as nonforest land.)

a. *Nonforest land without trees.*—Nonforest land with no live trees present.
b. *Nonforest land with trees.*—Nonforest land with one or more trees per acre at least 5 inches d.b.h.

Nonstocked land.—Forest land less than 16.7 percent stocked with all live trees.

Other forest land.—Forest land not capable of producing 20 cubic feet per acre per year of industrial wood crops under natural conditions and not associated with urban or rural development. These sites often contain tree species that are not currently utilized for industrial wood production or trees of poor form, small size, or inferior quality that are unfit for industrial products. Unproductivity may be the result of adverse site conditions such as sterile soil, dry climate, poor drainage, high elevation, and rockiness. This land is not withdrawn from timber utilization.

Poletimber stand.—(See Stand-size class.)

Poletimber tree.—A growing-stock tree of commercial species at least 5.0 inches d.b.h. but smaller than sawtimber size.

Potential productivity class.—A classification of forest lands in terms of inherent capacity to grow crops of industrial wood. The class identifies the potential growth in merchantable cubic feet/acre/year at culmination of mean annual increment of fully stocked natural stands.

Reserved forest land.—Forest land withdrawn from timber utilization through statute, administrative regulation, designation, or exclusive use for Christmas tree production, as indicated by annual shearing.

Rotten tree.—A tree that does not meet regional merchantability standards because of excessive unsound cull. May include noncommercial tree species.

Rough tree.—A tree that does not meet regional merchantability standards because of excessive sound cull. May include noncommercial tree species.

Salvable dead tree.—A standing or down dead tree considered merchantable by regional standards.

Sapling.—A live tree 1.0 to 5.0 inches d.b.h.

Sapling-seedling stand.—(See Stand-size class.)

Saw log.—A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight and with a minimum diameter outside bark (d.o.b.) for softwoods of 7.0 inches (9.0 inches for hardwoods) or other combinations of size and defect specified by regional standards.

Saw-log portion.—That part of the bole of sawtimber trees between the stump and the saw-log top.

Saw-log top.—The point on the bole of sawtimber trees above which a saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber stand.—(See Stand-size class.)

Sawtimber tree.—A growing-stock tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h.

Sawtimber volume.—Net volume of the saw-log portion of live sawtimber in board feet, International 1/4-inch rule (unless specified otherwise) from stump to a minimum 7 inches top diameter outside bark (d.o.b.) for softwoods and a minimum 9 inches top d.o.b. for hardwoods.

Seedling.—A live tree less than 1.0 inch d.b.h. that is expected to survive. Only softwood seedlings more than 6 inches tall and hardwood seedlings more than 1 foot tall are counted.

Short-log tree (rough tree).—Sawtimber-size trees of commercial species that contain at least one merchantable 8- to 11-foot saw log but not a 12-foot saw log.

Soft hardwoods.—Hardwood species with an average specific gravity less than 0.50 such as gum, yellow-poplar, cottonwood, red maple, basswood, and willow.

Softwoods.—Coniferous trees, usually evergreen, having needles or scale-like leaves.

Stand.—A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

Stand-age class.—Age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Stand-size class.—A classification of stocked (see Stocking) forest land based on the size class of live trees on the area; that is, sawtimber, poletimber, or seedlings and saplings.

a. Sawtimber stands.—Stands with half or more of live stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

b. Poletimber stands.—Stands with half or more live stocking in poletimber and/or sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

c. Sapling-seedling stands.—Stands with more than half of the live stocking in saplings and/or seedlings.

Stocking.—The degree of occupancy of land by live trees, measured by basal area and/or the number of trees in a stand by size or age and spacing, compared to the basal area and/or number of trees required to fully utilize the growth potential of the land; that is, the stocking standard.

A stocking percent of 100 indicates full utilization of the site and is equivalent to 80 square feet of basal area per acre in trees 5.0 inches d.b.h. and larger. In a stand of trees less than 5.0 inches d.b.h., a stocking percent of 100 would indicate that the present number of trees is sufficient to produce 80 square feet of basal area per acre when the trees reach 5.0 inches d.b.h.

Stands are grouped into the following stocking classes:

Overstocked stands.—Stands in which stocking of live trees is 133 percent or more.

Fully stocked stands.—Stands in which stocking of live trees is from 100.0 to 132.9 percent.

Medium stocked stands.—Stands in which stocking of live trees is from 60.0 to 99.9 percent.

Poorly stocked stands.—Stands in which stocking of live trees is from 16.7 to 59.9 percent.

Nonstocked areas.—Timberland on which stocking of live trees is less than 16.7 percent.

Timberland.—Forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included. Formerly called commercial forest land.

Tree.—A woody plant usually having one or more perennial stems, a more or less definitely formed crown of foliage, and a height of at least 12 feet at maturity.

Tree size class.—A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Upper stem portion.—That part of the bole of sawtimber trees above the saw log top to a minimum top diameter of 4.0 inches outside bark or to the point where the central stem breaks into limbs.

Urban and other areas.—Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; cemeteries; or other nonforest land not included in any other specified land use class.

Water.—Water Areas. Areas within a land mass persistently covered by water.

(A) Bureau of the Census.—Permanent inland water surfaces, such as lakes, reservoirs, and ponds at least 40 acres in area; and streams, sloughs, estuaries, and canals at least one-eighth of a statute mile wide.

(B) Noncensus.—Permanent inland water surfaces, such as lakes, reservoirs, and ponds from 1 to 39.9 acres in area; and streams, sloughs, estuaries, and canals from 120 feet to one-eighth of a statute mile wide.

TABLES

Table 1.—Area of land by county and major land-use class, Mark Twain National Forest, Missouri, 1989

Table 2.—Area of timberland by forest type and stand-size class, Mark Twain National Forest, Missouri, 1989

Table 3.—Area of timberland by forest type and potential productivity class, Mark Twain National Forest, Missouri, 1989

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Table 6.—Number of growing-stock trees on timberland by species group and diameter class, Mark Twain National Forest, Missouri, 1989

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Table 10.—Net volume of timber on timberland by class of timber and species group, Mark Twain National Forest, Missouri, 1989

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Table 12.—Average net annual growth and average annual removals of growing stock and sawtimber on timberland by species group, Mark Twain National Forest, Missouri, 1977-1989

Table 13.—Average annual mortality of growing stock and sawtimber on timberland by species group, Mark Twain National Forest, Missouri, 1977-1989

Table 1.--Area of land by county and major land-use class, Mark Twain National Forest, Missouri, 1989

(In thousand acres)

County	Land area	Forest land				
		All forest land	Timber-land	Timberland as a percent of land area	Other forest land	Reserved forest land
Barry	54.1	52.8	42.3	78.2	3.5	7.0
Bollinger	1.6	1.6	1.6	100.0	--	--
Boone	3.3	1.5	1.5	45.5	--	--
Butler	47.9	47.4	47.4	99.0	--	--
Callaway	11.7	6.6	6.6	56.4	--	--
Carter	90.2	90.2	90.2	100.0	--	--
Christian	51.3	49.8	41.5	80.9	8.3	--
Crawford	49.4	48.3	48.3	97.8	--	--
Dent	68.1	67.3	67.3	98.8	--	--
Douglas	41.2	39.2	37.1	90.0	2.1	--
Howell	49.0	47.9	47.9	97.8	--	--
Iron	96.8	94.1	81.2	83.9	4.5	8.4
Laclede	28.7	28.7	27.8	96.9	0.9	--
Madison	50.0	48.6	38.8	77.6	3.0	6.8
Oregon	98.1	94.8	71.0	72.4	--	23.8
Ozark	38.8	37.9	20.2	52.1	6.4	11.3
Phelps	63.6	62.5	62.5	98.3	--	--
Pulaski	46.9	44.8	44.8	95.5	--	--
Reynolds	88.9	85.5	85.5	96.2	--	--
Ripley	95.1	94.2	94.2	99.1	--	--
St. Francois	0.9	0.9	0.9	100.0	--	--
Ste. Genevieve	10.3	9.9	9.9	96.1	--	--
Shannon	83.6	83.4	83.4	99.8	--	--
Stone	16.3	15.9	14.7	90.2	--	1.2
Taney	63.7	62.4	44.7	70.2	4.9	12.8
Texas	48.2	47.0	38.6	80.1	--	8.4
Washington	82.4	78.1	78.1	94.8	--	--
Wayne	86.6	85.9	85.9	99.2	--	--
Wright	7.0	7.0	7.0	100.0	--	--
All counties	1,473.7	1,434.2	1,320.9	89.6	33.6	79.7

Table 2.--Area of timberland by forest type and stand-size class, Mark Twain National Forest, Missouri, 1989

(In thousand acres)

Forest type	All stands	Stand-size class			
		Sawtimber	Poletimber	Seedling & sapling	Nonstocked
Shortleaf pine	133.0	81.1	44.2	7.7	--
Eastern redcedar	4.0	--	1.3	2.7	--
E. redcedar-hardwood	26.4	8.5	15.6	2.3	--
Shortleaf pine-oak	140.3	72.2	43.8	24.3	--
Post-blackjack oak	108.2	37.6	33.5	37.1	--
Black-scarlet oak	564.4	362.1	127.1	75.2	--
White oak	314.5	127.9	115.7	70.9	--
Maple-beech	30.1	1.2	13.3	15.6	--
All types	1,320.9	690.6	394.5	235.8	--

Table 3.--Area of timberland by forest type and potential productivity class, Mark Twain National Forest, Missouri, 1989

(In thousand acres)

Forest type	All classes	Potential productivity class (cu.ft. of growth per acre per year)				
		165+	120-164	85-119	50-84	20-49
Shortleaf pine	133.0	--	--	--	--	133.0
Eastern redcedar	4.0	--	--	--	--	4.0
E. redcedar-hardwood	26.4	--	--	--	4.9	21.5
Shortleaf pine-oak	140.3	--	--	--	92.2	48.1
Post-blackjack oak	108.2	--	--	--	53.5	54.7
Black-scarlet oak	564.4	--	--	6.1	405.7	152.6
White oak	314.5	--	--	7.8	198.8	107.9
Maple-beech	30.1	--	--	--	6.8	23.3
All counties	1,320.9	--	--	13.9	761.9	545.1

Table 4.--Area of timberland by forest type and stocking class of growing-stock trees[1], Mark Twain National Forest, Missouri 1989

(In thousand acres)

Forest type	All classes	Stocking percent of growing-stock trees				
		Non-stocked	Poorly stocked	Moderately stocked	Fully stocked	Over-stocked
Shortleaf pine	133.0	--	--	45.2	67.6	20.2
Eastern redcedar	4.0	--	2.7	1.3	--	--
E. redcedar-hardwood	26.4	--	8.5	17.9	--	--
Shortleaf pine-oak	140.3	--	4.4	86.9	40.7	8.3
Post-blackjack oak	108.2	--	23.7	59.3	17.8	7.4
Black-scarlet oak	564.4	--	69.5	358.1	110.0	26.8
White oak	314.5	--	17.7	192.8	89.5	14.5
Oak-gum-cypress	--	--	--	--	--	--
Elm-ash-soft maple	--	--	--	--	--	--
Cottonwood	--	--	--	--	--	--
Maple-beech	30.1	--	1.2	20.1	0.7	8.1
Nonstocked	--	--	--	--	--	--
All types	1,320.9	--	127.7	781.6	326.3	85.3

[1] This table is based on the stocking percent of growing-stock trees rather than that of all live trees, therefore, to use the definitions of stocking for this table, replace the term "all live" by "growing-stock".

Table 5.--Number of all live trees on timberland by species group and diameter class, Mark Twain National Forest, Missouri, 1989

(In thousand trees)

Species group	All classes	Diameter class (inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods													
Shortleaf pine	68,282	13,755	13,626	16,393	11,295	6,443	3,671	1,925	806	270	98	--	--
Other yellow pines	32	--	--	--	32	--	--	--	--	--	--	--	--
Eastern redcedar	22,613	14,223	4,860	2,436	726	271	85	--	12	--	--	--	--
Total	90,927	27,978	18,486	18,829	12,053	6,714	3,756	1,925	818	270	98	--	--
Hardwoods													
Select white oak	146,399	65,103	36,271	20,012	10,156	6,104	3,445	2,495	1,504	708	362	220	19
Other white oak	64,171	30,978	16,183	6,673	4,294	2,469	1,653	1,047	537	195	63	79	--
Select red oak	8,868	2,214	2,445	1,409	807	710	430	314	285	143	58	49	4
Other red oak	129,547	46,559	27,384	15,734	14,102	9,425	7,469	4,838	2,442	860	465	255	14
Select hickory	30,127	18,904	6,579	1,853	1,291	703	519	210	45	17	6	--	--
Other hickory	84,601	57,213	16,553	4,652	2,702	1,708	1,099	475	151	48	--	--	--
Basswood	665	630	21	--	--	--	4	--	10	--	--	--	--
Hard maple	9,852	7,791	1,515	413	49	17	39	11	17	--	--	--	--
Soft maple	27,618	21,714	5,493	400	--	11	--	--	--	--	--	--	--
Elm	29,863	22,638	5,250	1,399	287	76	112	81	20	--	--	--	--
Ash	6,810	4,590	939	561	366	193	87	42	27	--	5	--	--
Sycamore	308	--	--	--	--	146	54	34	19	45	5	5	--
Willow	247	90	--	157	--	--	--	--	--	--	--	--	--
Hackberry	2,788	2,505	135	34	58	34	5	17	--	--	--	--	--
Sweetgum	725	456	--	87	--	182	--	--	--	--	--	--	--
Tupelo	35,728	28,731	5,268	792	440	103	123	91	70	56	27	25	2
Black cherry	6,693	4,929	1,131	356	210	67	--	--	--	--	--	--	--
Black walnut	2,118	882	21	351	296	287	195	60	18	--	8	--	--
Persimmon	4,128	3,435	576	117	--	--	--	--	--	--	--	--	--
Sassafras	23,408	21,090	2,187	131	--	--	--	--	--	--	--	--	--
Other hardwoods	130,065	114,572	13,505	1,837	116	--	34	1	--	--	--	--	--
Noncommercial sp.	15,416	13,074	1,740	551	51	--	--	--	--	--	--	--	--
Total	760,145	468,098	143,196	57,519	35,225	22,235	15,268	9,716	5,145	2,072	999	633	39
All species	851,072	496,076	161,682	76,348	47,278	28,949	19,024	11,641	5,963	2,342	1,097	633	39

Table 6.--Number of growing-stock trees on timberland by species group and diameter class, Mark Twain National Forest, Missouri, 1989

(In thousand trees)

Species group	All classes	Diameter class (inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods													
Shortleaf pine	66,569	13,755	13,344	15,831	10,742	6,296	3,541	1,897	806	259	98	--	--
Other yellow pines	32	--	--	--	32	--	--	--	--	--	--	--	--
Eastern redcedar	21,812	14,223	4,563	2,249	583	171	23	--	--	--	--	--	--
Total	88,413	27,978	17,907	18,080	11,357	6,467	3,564	1,897	806	259	98	--	--
Hardwoods													
Select white oak	135,997	65,103	33,322	17,624	8,812	5,225	2,466	1,791	925	465	202	62	--
Other white oak	55,806	30,978	13,611	5,362	2,876	1,708	639	459	135	29	9	--	--
Select red oak	7,681	2,214	2,445	1,027	732	480	311	214	173	48	20	17	--
Other red oak	110,245	45,990	23,388	11,566	10,826	7,227	5,195	3,545	1,689	548	182	89	--
Select hickory	27,655	18,904	5,538	1,402	968	402	340	79	22	--	--	--	--
Other hickory	79,487	56,773	15,344	3,429	1,720	1,047	688	355	105	26	--	--	--
Basswood	655	630	21	--	--	--	4	--	--	--	--	--	--
Hard maple	9,341	7,791	1,431	92	7	--	7	11	2	--	--	--	--
Soft maple	26,095	21,618	4,428	49	--	--	--	--	--	--	--	--	--
Elm	27,698	22,638	4,185	581	213	--	32	49	--	--	--	--	--
Ash	5,391	4,491	558	73	90	138	26	15	--	--	--	--	--
Sycamore	221	--	--	--	--	86	49	34	19	33	--	--	--
Willow	90	90	--	--	--	--	--	--	--	--	--	--	--
Hackberry	2,472	2,421	--	--	--	34	--	17	--	--	--	--	--
Sweetgum	725	456	--	87	--	182	--	--	--	--	--	--	--
Tupelo	34,635	28,731	4,839	556	269	76	50	40	31	26	8	7	2
Black cherry	5,779	4,929	705	145	--	--	--	--	--	--	--	--	--
Black walnut	1,459	882	--	192	67	223	45	42	--	--	8	--	--
Persimmon	3,914	3,435	435	44	--	--	--	--	--	--	--	--	--
Sassafras	22,425	21,090	1,335	--	--	--	--	--	--	--	--	--	--
Other hardwoods	122,186	113,745	7,698	743	--	--	--	--	--	--	--	--	--
Total	680,386	453,338	119,283	42,972	26,580	16,828	9,852	6,651	3,101	1,175	429	175	2
All species	768,799	481,316	137,190	61,052	37,937	23,295	13,416	8,548	3,907	1,434	527	175	2

Table 7.--Net volume of growing-stock trees on timberland by species group and diameter class, Mark Twain National Forest, Missouri, 1989

(In thousand cubic feet)

Species group	All classes	Diameter class (inches at breast height) 5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods											
Shortleaf pine	295,908	37,763	54,581	59,673	54,875	44,291	26,760	12,054	5,911	--	--
Other yellow pines	170	--	170	--	--	--	--	--	--	--	--
Eastern redcedar	8,200	4,269	2,278	1,387	266	--	--	--	--	--	--
Total	304,278	42,032	57,029	61,060	55,141	44,291	26,760	12,054	5,911	--	--
Hardwoods											
Select white oak	266,133	40,705	43,100	46,022	36,265	38,573	28,035	18,571	10,602	4,260	--
Other white oak	62,164	11,289	12,394	15,020	8,875	9,428	3,637	1,080	441	--	--
Select red oak	30,387	2,528	4,038	4,441	4,937	4,654	5,192	2,138	1,148	1,311	--
Other red oak	388,647	26,776	53,129	65,908	75,940	76,788	51,428	22,630	9,791	6,257	--
Select hickory	19,767	2,900	4,763	4,202	5,328	1,715	859	--	--	--	--
Other hickory	50,890	7,895	8,144	10,249	11,179	8,758	3,336	1,329	--	--	--
Basswood	50	--	--	--	50	--	--	--	--	--	--
Hard maple	664	216	45	--	110	228	65	--	--	--	--
Soft maple	152	152	--	--	--	--	--	--	--	--	--
Elm	3,351	999	838	--	482	1,032	--	--	--	--	--
Ash	2,310	128	367	1,107	415	293	--	--	--	--	--
Sycamore	5,307	--	--	1,096	911	868	824	1,608	--	--	--
Willow	--	--	--	--	--	--	--	--	--	--	--
Hackberry	654	--	--	288	--	366	--	--	--	--	--
Sweetgum	2,108	192	--	1,916	--	--	--	--	--	--	--
Tupelo	8,078	1,262	1,190	687	708	897	1,089	1,032	449	435	329
Black cherry	326	326	--	--	--	--	--	--	--	--	--
Black walnut	4,489	465	314	1,813	644	826	--	--	427	--	--
Persimmon	74	74	--	--	--	--	--	--	--	--	--
Sassafras	--	--	--	--	--	--	--	--	--	--	--
Other hardwoods	1,084	1,084	--	--	--	--	--	--	--	--	--
Total	846,635	96,991	128,322	152,749	145,844	144,426	94,465	48,388	22,858	12,263	329
All species	1,150,913	139,023	185,351	213,809	200,985	188,717	121,225	60,442	28,769	12,263	329

Table 8.--Net volume of sawtimber trees on timberland by species group and diameter class, Mark Twain National Forest, Missouri, 1989

(In thousand board feet)[1]

Species group	All classes	Diameter class (inches at breast height) 9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods									
Shortleaf pine	1,049,849	297,508	281,318	231,821	142,023	65,047	32,132	--	--
Other yellow pines	--	--	--	--	--	--	--	--	--
Eastern redcedar	8,987	7,602	1,385	--	--	--	--	--	--
Total	1,058,836	305,110	282,703	231,821	142,023	65,047	32,132	--	--
Hardwoods									
Select white oak	652,858	--	178,528	186,952	133,314	86,733	48,463	18,868	--
Other white oak	117,667	--	44,973	47,085	18,205	5,289	2,115	--	--
Select red oak	96,244	--	24,439	23,207	25,971	10,623	5,674	6,330	--
Other red oak	1,200,967	--	376,048	381,269	254,718	111,221	47,742	29,969	--
Select hickory	38,220	--	25,749	8,299	4,172	--	--	--	--
Other hickory	122,273	--	55,474	43,597	16,563	6,639	--	--	--
Basswood	252	--	252	--	--	--	--	--	--
Hard maple	1,923	--	526	1,087	310	--	--	--	--
Soft maple	--	--	--	--	--	--	--	--	--
Elm	7,006	--	2,255	4,751	--	--	--	--	--
Ash	3,233	--	1,884	1,349	--	--	--	--	--
Sycamore	19,511	--	4,085	3,910	3,878	7,638	--	--	--
Willow	--	--	--	--	--	--	--	--	--
Hackberry	1,667	--	--	1,667	--	--	--	--	--
Sweetgum	--	--	--	--	--	--	--	--	--
Tupelo	22,302	--	3,271	4,126	4,960	4,712	2,020	1,929	1,284
Black cherry	--	--	--	--	--	--	--	--	--
Black walnut	9,082	--	3,096	3,982	--	--	2,004	--	--
Persimmon	--	--	--	--	--	--	--	--	--
Sassafras	--	--	--	--	--	--	--	--	--
Other hardwoods	--	--	--	--	--	--	--	--	--
Total	2,293,205	--	720,580	711,281	462,091	232,855	108,018	57,096	1,284
All species	3,352,041	305,110	1,003,283	943,102	604,114	297,902	140,150	57,096	1,284

[1] International 1/4-inch rule.

Table 9.--Net volume of growing stock and sawtimber on timberland by county and species group, Mark Twain National Forest, Missouri, 1989

County	Growing stock					Sawtimber				
		Species group					Species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Thousand cubic feet					*Thousand board feet* [1]				
Barry	33,037	2,298	--	439	30,300	86,437	2,179	--	--	84,258
Bollinger	1,030	--	--	--	1,030	2,215	--	--	--	2,215
Boone	1,512	--	--	--	1,512	4,422	--	--	--	4,422
Butler	56,285	17,657	--	192	38,436	179,043	68,031	--	--	111,012
Callaway	2,632	--	338	229	2,065	5,590	--	367	989	4,234
Carter	73,210	27,093	138	1,475	44,504	199,248	90,614	--	4,851	103,783
Christian	19,389	--	544	181	18,664	61,716	--	--	252	61,464
Crawford	36,449	813	266	1,843	33,527	108,248	--	1,385	6,597	100,266
Dent	52,512	15,841	--	1,012	35,659	160,710	56,164	--	3,064	101,482
Douglas	44,724	15,911	--	142	28,671	150,343	77,821	--	--	72,522
Howell	54,635	23,294	151	221	30,969	167,989	74,708	--	--	93,281
Iron	81,037	12,974	--	679	67,384	236,887	56,777	--	1,810	178,300
Laclede	18,598	6,761	203	--	11,634	20,751	2,639	--	--	18,112
Madison	36,506	6,733	246	766	28,761	98,350	23,453	--	2,020	72,877
Oregon	57,325	11,442	--	2,743	43,140	153,578	36,423	--	8,171	108,984
Ozark	18,135	9,460	25	--	8,650	33,082	17,379	--	--	15,703
Phelps	54,323	22,081	--	1,011	31,231	104,615	31,111	--	4,040	69,464
Pulaski	30,143	6,712	--	587	22,844	80,164	19,465	--	2,480	58,219
Reynolds	89,907	14,707	--	579	74,621	289,425	60,769	--	1,285	227,371
Ripley	105,063	32,471	--	5,470	67,122	370,046	154,214	--	11,174	204,658
St. Francois	868	39	--	--	829	3,558	--	--	--	3,558
Ste. Genevieve	9,851	--	--	--	9,851	29,576	--	--	--	29,576
Shannon	72,018	27,047	--	152	44,819	236,012	111,985	--	--	124,027
Stone	5,611	--	1,434	--	4,177	9,121	--	1,145	--	7,976
Taney	18,760	231	4,303	654	13,572	33,872	--	3,014	1,667	29,191
Texas	29,283	14,835	280	507	13,661	99,191	60,950	1,596	--	36,645
Washington	65,763	11,159	272	199	54,133	177,691	42,543	1,480	--	133,668
Wayne	78,683	16,003	--	945	61,735	243,863	62,624	--	2,338	178,901
Wright	3,624	516	--	--	3,108	6,298	--	--	--	6,298
All counties	1,150,913	296,078	8,200	20,026	826,609	3,352,041	1,049,849	8,987	50,738	2,242,467

[1] International 1/4-inch rule.

Table 10.--Net volume of timber on timberland by class of timber and species group, Mark Twain National Forest, Missouri, 1989

(In thousand cubic feet)

Class of timber	All species	Species group			
		Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Live trees					
Growing-stock trees					
Sawtimber					
Saw-log portion	566,296	180,826	1,368	9,325	374,777
Upper stem portion	107,494	22,738	285	1,755	82,716
Total	673,790	203,564	1,653	11,080	457,493
Poletimber	477,123	92,514	6,547	8,946	369,116
All growing-stock trees	1,150,913	296,078	8,200	20,026	826,609
Cull trees					
Short-log trees	61,376	1,487	378	517	58,994
Rough trees					
Sawtimber	127,107	992	1,171	1,814	123,130
Poletimber	92,221	3,421	933	6,073	81,794
Total	219,328	4,413	2,104	7,887	204,924
Rotten trees					
Sawtimber	51,686	591	--	4,363	46,732
Poletimber	9,097	--	6	684	8,407
Total	60,783	591	6	5,047	55,139
All cull trees	341,487	6,491	2,488	13,451	319,057
All live trees	1,492,400	302,569	10,688	33,477	1,145,666
Salvable dead trees					
Sawtimber	10,310	2,139	--	--	8,171
Poltetimber	5,586	1,179	--	--	4,407
Total	15,896	3,318	--	--	12,578
All classes of timber	1,508,296	305,887	10,688	33,477	1,158,244

Table 11.--Net volume of sawtimber trees on timberland by species group and butt log grade, Mark Twain National Forest, Missouri, 1989

(In thousand board feet)[1]

Species group	All grades	Butt log grade			
		1	2	3	Tie and timber
Softwoods					
Shortleaf pine	1,049,849	20,922	227,291	801,635	--
Other yellow pines	--	--	--	--	--
Eastern redcedar	8,987	--	--	8,987	--
Total	1,058,836	20,922	227,291	810,622	--
Hardwoods					
Select white oak	652,858	7,233	64,230	244,006	337,390
Other white oak	117,667	--	2,190	37,280	78,197
Select red oak	96,244	--	--	17,200	79,044
Other red oak	1,200,967	--	24,558	216,423	959,986
Select hickory	38,220	--	--	5,886	32,334
Other hickory	122,273	--	5,154	46,446	70,673
Basswood	252	--	--	--	252
Hard maple	1,923	--	--	1,087	836
Soft maple	--	--	--	--	--
Elm	7,006	--	1,252	409	5,345
Ash	3,233	--	--	3,233	--
Sycamore	19,511	--	--	12,757	6,754
Willow	--	--	--	--	--
Hackberry	1,667	--	1,667	--	--
Sweetgum	--	--	--	--	--
Tupelo	22,302	--	--	11,970	10,332
Black cherry	--	--	--		--
Black walnut	9,082	--	--	5,100	3,982
Persimmon	--	--	--	--	--
Sassafras	--	--	--	--	--
Other hardwoods	--	--	--	--	--
Total	2,293,205	7,233	99,051	601,796	1,585,126
All species	3,352,041	28,155	326,342	1,412,419	1,585,126

[1] International 1/4-inch rule.

2 Includes 3,074 thousand board feet of volume from sawtimber-sized, Grade 5 eastern redcedar trees graded for special use. (See Log Grades for Eastern Redcedar in the Appendix.)

Table 12.--Average net annual growth and average annual removals of growing stock and sawtimber on timberland by species group, Mark Twain National Forest, Missouri, 1977-1989

Species group	Growing stock		Sawtimber	
	Growth	Removals	Growth	Removals
	Thousand cubic feet		*Thousand board feet* [1]	
Softwoods				
Shortleaf pine	8,387	4,579	42,196	15,772
Other yellow pines	15	--	--	--
Eastern redcedar	330	33	410	--
Total	8,732	4,612	42,606	15,772
Hardwoods				
Select white oak	10,027	3,664	27,517	9,735
Other white oak	1,311	1,390	2,437	4,490
Select red oak	735	625	2,780	1,593
Other red oak	10,594	6,579	53,614	22,867
Select hickory	117	273	-6	194
Other hickory	630	639	2,188	2,277
Basswood	--	--	25	--
Hard maple	2	--	-56	--
Soft maple	1	--	--	--
Elm	87	93	160	84
Ash	-338	88	-1,500	--
Sycamore	127	--	483	--
Willow	--	--	--	--
Hackberry	4	--	7	--
Sweetgum	66	--	--	--
Tupelo	117	58	332	191
Black cherry	50	24	--	--
Black walnut	39	32	-117	151
Persimmon	--	--	--	--
Sassafras	--	--	--	--
Other hardwoods	36	--	--	--
Total	23,605	13,465	87,864	41,582
All species	32,337	18,077	130,470	57,354

[1] International 1/4-inch rule.

Table 13.--Average annual mortality of growing stock and sawtimber on timberland by species group, Mark Twain National Forest, Missouri, 1977-1989

Species group	Growing stock	Sawtimber
	Thousand cubic feet	*Thousand board feet* [1]
Softwoods		
Shortleaf pine	1,493	3,866
Other yellow pines	--	--
Eastern redcedar	--	2
Total	1,493	3,868
Hardwoods		
Select white oak	610	1,707
Other white oak	465	1,181
Select red oak	406	1,424
Other red oak	5,832	15,754
Select hickory	175	506
Other hickory	578	1,078
Basswood	--	--
Hard maple	1	--
Soft maple	--	--
Elm	60	--
Ash	122	143
Sycamore	43	147
Willow	--	--
Hackberry	--	--
Sweetgum	4	--
Tupelo	10	15
Black cherry	1	--
Black walnut	36	158
Persimmon	--	--
Sassafras	--	--
Other hardwoods	5	--
Total	8,348	22,113
All species	9,841	25,981

[1] International 1/4-inch rule.

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Presents highlights and statistics on area, volume, growth, removals, and mortality from the 1989 forest inventory of the Mark Twain National Forest.

KEY WORDS: Area, volume, growth, removals, mortality.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.